Appendix A
Research, Engineering and Development Advisory Committee

The FAA values the ongoing involvement of the R,E&D Advisory Committee in reviewing its current and planned R,E&D programs. A formal process has been established whereby the agency replies to the Committee's reports. This document summarizes recent Committee recommendations and FAA responses.

During 1998, the FAA responded to four Committee reports. Two of the responses were updates to previously provided FAA responses. One of these was an updated response to the *Human Factors Subcommittee Report,* dated August 1996, to which the FAA originally responded on January 28, 1997. The second was the FAA's final response to the *NAS ATM R&D Panel Report,* dated March 25, 1997, for which the FAA provided an initial response on September 9, 1997. The Committee submitted three reports in 1998. The FAA responded to the *Report and Minutes of the Subcommittee on Air Traffic Services*. The other two reports submitted in 1998, were the *Committee's Recommendations on FY 2000 R,E&D Investment,* dated April 1998, to which the FAA plans to respond between January and April 1999, and the *Report of the Subcommittee on Runway Incursion.*

In total, this section provides recommendations from four Committee reports (listed below) and FAA responses to the first three reports on the list.

- *Human Factors Subcommittee Report* (dated August 1996—updated response)

- *NAS ATM R&D Panel Report* (dated March 25, 1997—updated response)

- *Report and Minutes of the Subcommittee on Air Traffic Services* (dated November 6, 1997)

- *Committee's Recommendations on FY 2000 R,E&D Investments* (dated April 23, 1998—response pending)

In 1999, the FAA expects to receive the Committee's recommendations on planned FAA research and development investments for fiscal year 2001, which will include detailed recommendations from the standing subcommittees.

Updated Response to the *Human Factors Subcommittee Report* (Report dated August 1996)

In September 1994, the Advisory Committee chartered a Human Factors Subcommittee under the Chairmanship of Dr. Earl L. Wiener. The purpose of the Subcommittee was to investigate, assess, and report on the status and organization of the human factors program in the FAA, and make recommendations for improvements.

Dr. Maureen Pettitt, FAA Chief Scientific and Technical Advisor for Human Factors, addressed the following recommendations from the Subcommittee's August 1996 report during the Committee meeting on January 29–30, 1998.

The responses below are an update to the responses the Committee received at the January 28, 1997 meeting, which were published in the 1998 FAA Plan for Research, Engineering and Development.

Recommendation: Centralize responsibility for Human Factors in the FAA.

***Response*:** A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group also agreed that there should be a centralized responsibility for FAA human factors, adequately resourced and that

AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Recommendation: Assign resources and people to this central responsible structure, define the agency's expectation, and hold [those assigned] accountable.

***Response*:** A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group agreed that there should be a centralized responsibility for FAA human factors, adequately resourced, and that AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Recommendation: Provide an agency lead organization for Human Factors.

Response: A human factors group was convened as a result of human factors issues surrounding the STARS system. This process group agreed that there should be a centralized responsibility for FAA human factors, adequately resourced, and that AAR-100 should be designated as the lead in this effort. An implementation plan is under development.

Updated Response to the *NAS ATM R&D Panel Report* (Report dated March 25, 1997)

The National Airspace Systems (NAS) Research and Development (R&D) Panel was an ad hoc subcommittee chartered to review the content and management of FAA's current R&D program against the proposed NAS Architecture. The purpose of the review was to identify issues that require resolution in order to complete the architecture and to explore opportunities for increasing the programs' effectiveness in enhancing the NAS.

The Subcommittee's report dated March 25, 1997, was approved by the Committee on April 9, 1997 and provided by letter to the Administrator on April 17. The report provided recommendations in six areas: management, advanced ATM, software engineering, aviation weather, system capacity, and leveraging.

The following response is considered the final response and is an update to FAA's initial response, which was provided on September 9, 1997 and published in the 1998 FAA Plan for Research, Engineering and Development. The final response was provided to the Committee by letter dated July 9, 1998.

Management Issues

Recommendation: Create a new Deputy Administrator position for the National Airspace System (NAS), with responsibility for research, development, acquisition, operation, and maintenance of the NAS.

Recommendation: Elevate the Federal Aviation Administration (FAA) system engineering function to a very high level (administrator or deputy administrator level) to promote/allow aviation-wide solutions, decisions and development to occur quickly.

Response: The National Civil Aviation Review Commission (NCARC) report was published last December. The report recommends a performance-based Air Traffic Services (ATS) organization, which would encompass air traffic services and engineering functions. The NCARC recommendations will be resolved within the Administration and with Congress over the March-to-October time frame. It is expected that the subject matter of these recommendations will be addressed in the process.

Recommendation: Reverse the losses of technically competent and highly experienced and skilled FAA personnel crucial to effectively manage technology changes and to provide the necessary leadership to manage contractor efforts.

Response: The Associate Administrator for Research and Acquisitions (ARA) is developing an Intellectual Capital Investment Plan to foster more effective recruitment, development, and retention of its work force.

Recommendation: Develop the ability to plan and fund the continuous insertion of evolving technology into the NAS.

Response: The NAS Architecture provides for continuous technology insertion over the life cycle of systems.

Advanced ATM

Recommendation: A "strawman" vision, with broad agency support, of the evolution of the NAS including functionality, concepts of operation, architecture, transition mechanisms, and environmental and safety considerations, is required to provide a basis for the research and development (R&D) investment process.

Response: The FAA agrees. During the course of the past year, the FAA has developed a concept of operations for the NAS in the year 2005. It was developed by ATS, with support from the Associate Administrator for Certification and Regulation (AVR), and ARA. This broad support within the agency reflects continued migration of the NAS from a ground-based infrastructure to one that encompasses both ground- and space-based systems. The participation of these organizations also demonstrates recognition of the need to engage the operational components of the FAA early in the concept formulation process.

The current concept of operations for the NAS presents a high-level description of air traffic operations in 2005. The concept does not describe an end-state system architecture. Instead, the concept defines an initial change in the air traffic environment and lays the groundwork for transitional phases subsequent to 2005.

Over the past several months, the Administrator has convened two meetings of a NAS Modernization Task Force to identify a near-term plan for system modernization that best applies available resources to the needs of the agency's customer community. The work of the task force has been based on the operational concept for 2005 and NAS Architecture Version 3.0. The FAA will continue to develop and refine a community-supported concept of operations for the future and to maintain a NAS architecture consistent with that operational concept and consistent with the FAA budget.

Recommendation: Increase emphasis on understanding the implications of various Free Flight architectural alternatives on pilot and controller performance and incorporate this understanding early in the NAS architecture evolution process. Continue the collaborative efforts between FAA and the National Aeronautics and Space Administration (NASA) in this area.

Response: The FAA agrees with this recommendation and believes that several ongoing and new initiatives will provide the emphasis necessary to achieve the appropriate level of understanding of Free Flight human factors and related human performance alternatives. The FAA recognizes the critical role of human performance in NAS architecture development and has taken steps to address the issues. These steps include: (1) conducting human factors research studies, (2) preparing human factors research and application inputs to the NAS Architecture Version 3.0, (3) establishing a working group to identify future human performance research requirements, (4) establishing a human factors working group to support the Flight 2000 demonstration and to provide connectivity to Free Flight human factors requirements, and (5) working with NASA to develop a coordi-

nated research program that addresses Free Flight human performance issues.

Recommendation: Safety considerations need to be explicitly included in NAS concept evaluation. R&D is required to support the development of methods to evaluate safety and environmental impacts.

Response: The FAA agrees. During the course of the past year, the FAA and NASA have conducted collaborative modeling and analysis activities through the Interagency Integrated Product Team (IPT) directed at evaluating safety implications associated with potential future air traffic scenarios. These scenarios incorporate systematic reductions in restrictions associated with the current system concept of operations. These analyses will provide information regarding conflict geometry, closing velocities, aircraft densities, and other measures that will assist in the evaluation of safety associated with potential future operational concepts. Scenarios that reflect future demand are being prepared and will be analyzed during the upcoming year. These scenarios and analyses will be used also to support future environmental impact evaluation activities.

The processes for end-to-end safety assessments for air and ground systems are being developed jointly by RTCA Special Committee 189 and EUROCAE Working Group 53. Concurrently, FAA Safety Assessments Working Group is developing procedures and tolls for safety assessments within the Acquisition Management System specifically targeted at NAS modernization. A new agency policy order is in final coordination and will require safety risk assessments.

Recommendation: Efforts should be continued to improve the analytical basis on which to support NAS evolution decisions. These efforts should include improving the understanding of the current air traffic control (ATC) system, the theoretical basis of ATC, and the development and use of fast time models.

Response: FAA continues to strengthen the analytical basis of evolution decisions. This is done by applying fast time models such as SIMMOD[1], NASPAC[2], and RAMS[3] to evaluate alternative

1.   A trademark name for the FAA's Airport and Airspace Simulation Model
2.   National Airspace System Performance Analysis Capability
3.   Reorganized Mathematical Air Traffic Control Simulator

NAS concepts and to guide investment decision-making in the NAS. While some models to support this work exist, the lack of sufficient funding hampers further development and widespread use.

Recommendation: Continue collaboration between FAA and NASA. Work to maintain a relationship which will promote the most effective joint R&D program supporting domestic and international air traffic management (ATM) evolution.

Response: The FAA agrees with this recommendation, and is continuing to work with NASA to ensure that the joint ATM R&D activities are responsive to user needs.

The ATM R&D program within the United States is being coordinated with the European Organization for the Safety of Air Navigation (Eurocontrol) and the European national administrations through a memorandum of cooperation between the FAA and Eurocontrol. This is intended to ensure that international ATM evolution is coordinated and convergent upon a worldwide seamless operational environment, and allows further opportunities for collaborative R&D and leveraging of R&D resources within the international ATM community.

Recommendation: Continue the coordination with international organizations working on NAS issues and build a combined stakeholder/technical consensus on NAS evolution.

Response: The FAA strongly agrees with this recommendation and is actively supporting this recommendation through multiple international initiatives. The FAA has established bilateral R&D agreements with a number of international civil aviation organizations. Through these agreements, the FAA is able to build a combined stakeholder/technical consensus on NAS evolution, and to ensure a consistent progression toward a global, seamless communications, navigation, and surveillance/air traffic management (CNS/ATM) system for the 21st century.

The FAA and Eurocontrol have defined several R&D cooperative tasks, assigned FAA and Eurocontrol points of contact to lead each task, and established a FAA/Eurocontrol R&D Committee to provide the management oversight and guidance necessary for progressing the R&D cooperative tasks. One of these tasks provides a framework by which the FAA coordinates the development and gains support for its NAS architecture within the European community.

In addition to the ongoing initiatives with Europe, the FAA is actively engaged in R&D initiatives with countries within the Asia-Pacific region. The FAA has established a cooperative working relationship with Japan and Australia regarding the Global Positioning System (GPS) and the Wide Area Augmentation System (WAAS) in support of the evolution of a Global Navigation Satellite System (GNSS).

The FAA also works very closely with numerous other countries within the International Civil Aviation Organization (ICAO) regional planning groups, task forces, and panels. In this way, issues are being addressed and coordinated at both the management and technical levels.

Software Engineering

Research and Development

Recommendation #1: The FAA should elevate the position of Chief Scientist for Software Engineering so that it directly reports to the Associate Administrator for Research and Acquisitions. The responsibilities associated with this position should include oversight for software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers. This position should be staffed by a nationally recognized software expert to interface with Government, industry, and academic organizations doing research in software to improve FAA insight and leverage.

Response: FAA agrees with the spirit of this recommendation and believes that developments in the FAA since 1990, when the Office of Information Technology was created, are in keeping with an orderly program intended to elevate the importance of software engineering throughout the FAA. Currently, the Chief Scientist for Software Engineering, a position that was created a little over 2 years ago, reports to the Director of the Office of Information Technology. This director also serves as the Chief Information Officer for the FAA and reports to the Associate Administrator for Research and Acquisitions. We believe that this represents an optimum solution at this time,

since it makes available the resources of the Office of Information Technology to the Chief Scientist for Software Engineering, as needed, and allows software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers to be coordinated with all of the other software activity occurring throughout the FAA.

The first Chief Scientist for Software Engineering, Dr. Floyd Hollister, was an internationally recognized software scientist recruited from the Software Engineering Institute of Carnegie-Mellon University. The incumbent, Dr. Art Pyster, was recruited into the FAA from the Software Productivity Consortium, a well known, non-profit software research institute. Dr. Pyster is an internationally recognized software scientist. His duties include oversight of software engineering policy, procedures, techniques, and technology used throughout the FAA and by its suppliers, and he interfaces with Government, industry, and academic organizations doing research in software to improve FAA insight and leverage.

Recommendation #2: The FAA should establish a software engineering laboratory under the direction of the Chief Scientist for Software Engineering that performs as a center of excellence to provide in-house capability in state-of-the-art software engineering technology and processes. The laboratory should be staffed by a small, high-competency team of recognized software engineering experts who would leverage their skills across the FAA organization. The Software Engineering Lab (SEL) mission would include:

- Education: Develop and present software engineering and relevant technology courses that are tailored to the needs of the FAA.

- Consultation: Have a cadre of software engineers available to provide technical and managerial expertise to FAA projects and research initiatives.

- Guidance: Provide software engineering guidance to FAA organizations on all aspects of system acquisition to include evaluation of vendor proposals and evaluation of work in progress.

Response: The FAA agrees. Budget item A02j, titled, "Software Engineering R&D," has been entered into the FY 1999 R,E&D budget submission to Congress. This item addresses two proposed software R&D efforts, the second of which is for a center for software engineering to provide a 'virtual' facility using resources at the FAA William J. Hughes Technical Center and with nodes located at university, Government agency, and other research facilities contributing to the activities of the center. The purpose of the center is to organize research critical to improving the safe use of software within the FAA and the aviation community generally.

Recommendation #3: The FAA should investigate the Department of Defense's (DOD) initiative in domain-specific software architectures (DSSA) to determine how the concept can be used to improve software reuse (and hence productivity) and software reliability. The FAA should consult with experts like Dr. Barry Boehm, who was instrumental in initiating DSSA concepts within the DOD, to guide development and implementation of DSSA concepts within the FAA.

Response: The FAA agrees. The FAA has become an Affiliate of the University of Southern California Center for Software Engineering, which will make available the services of Dr. Barry Boehm and other Center staff, as necessary. The FAA recognizes that any approach to reengineering the NAS, and the broader FAA information complex of which the NAS is a part, will require substantial innovation in the area of software architectures.

The center for software engineering (Recommendation #2) will provide a facility where various architectures and architectural innovations can be tested.

Recommendation #4: The FAA should increase the scope and elevate the importance of security engineering. In the environment of increasing automation, reliance on communications, and the sophistication of automated techniques used by malicious persons to penetrate systems, it is no longer adequate for the FAA security focus to be limited to the physical aspects of the NAS. Research must be applied to address the information warfare aspects associated with flight critical systems.

Response: The FAA agrees and has established a security architecture team within the System Architecture Office, ASD-110, led by Dr. Feisal Keblawi. This team has launched several major initiatives, including an inventory of the various NAS information security activities ongoing or planned. To organize and coordinate these activities better and to increase their combined effectiveness, the NAS Information Security (NIS) Group has been formed with Dr. Keblawi as chair and Dennis Hupp, ACO-3, as co-chair. The group, which includes a cross section of FAA operational and technical offices, was approved by the FAA Joint Resource Council (JRC) as an FAA Standing Committee on May 1, 1997.

This group has developed an action plan for implementing information security (INFOSEC). The plan is now in coordination, and the NIS Group has commenced working on a number of activities described in the plan. These include working with IPT's in supporting vulnerability assessments; holding INFOSEC workshops; performing a general INFOSEC program review; supporting development of updated INFOSEC policy; and developing a security engineering process. The group will serve as the overseer of all aspects of FAA INFOSEC (policy, procedures, management, training, assessment, analysis, security engineering, and security technology insertion).

Although the NIS Group has an aggressive plan for implementing INFOSEC, the availability of funding will have an impact on the timely implementation of their efforts, especially with regard to NIS research.

Recommendation #5: The FAA should increase the emphasis on enhancing standard processes and continuous process improvement.

Response: The FAA agrees and believes that our current process improvement strategy, plans, and activities are fully in concert with this recommendation. The associate administrators in three lines of business have committed to support FAA-wide process improvement based on capability maturity models. In particular, ARA has committed to increasing to FAA capability maturity model (CMM) Level 2 (or equivalent) by December 1999, and to Level 3 by December 2001, the process maturity of 75 percent of selected major software-intensive programs.

In addition, FAA has developed an integrated CMM (iCMM) reference model, which merges the three CMM's for systems engineering, software acquisition, and software development following the latest CMM integration guidelines from the Software Engineering Institute. The agency is using the iCMM to guide its process improvement efforts. FAA expects this model to help develop and improve integrated cross-disciplinary processes more effectively and efficiently for the full acquisition life cycle.

The FAA has set aggressive improvement goals and will continue to improve the processes that it uses to manage, acquire, and engineer software-intensive systems.

Recommendation #6: Establish a program for standardizing data element definitions for all FAA software-intensive systems, and mandate that all integrated product teams (IPT) utilize these definitions in all systems developments, whether in-house or by contract. Make conformance with the standard data elements an important consideration in the selection of commercial off-the-shelf (COTS) systems.

Response: The FAA agrees with the recommendation and believes that the data standardization processes being established are needed to accomplish the ultimate goal of Free Flight through seamless NAS interoperability and collaborative decisionmaking. The information architecture will be more integrated with the rest of the NAS data/service users and data/service providers in NAS architecture. An FAA-wide NAS Information Architecture Committee (NIAC) has been established and currently has three subcommittees working: (1) the Traffic Flow Management (TFM) Common Data Working Group; (2) the Host Information Architecture Group, and (3) the MITRE Information Architecture Support Group. Through the auspices of the NIAC, a "user-friendly" process is being instituted by which NAS stakeholders can collaborate in establishing standards for common NAS data elements and populating a NAS information directory or metadata repository. The goal is to integrate the agreed-to standard data formats and definitions into FAA's acquisition tools so vendors can start to build toward FAA-wide interface standards.

Recommendation #7: A research program should be established to address:

(1) ground system as well as airborne system certification, (2) improvements in the certification process to accommodate the ever-increasing pace of software change due to technology insertion or defect correction, and (3) certification of safety-critical systems that contain COTS software components. The FAA should determine whether it is feasible to characterize COTS suitability for inclusion in safety-critical systems and to quantify this suitability.

Response: The FAA agrees. The FAA COTS/ Non-developmental item (NDI) program was launched in May 1997, with the express goal of providing guidance on the acquisition of CNS/ ATM ground and ground-air systems incorporating COTS/NDI. The program is co-sponsored by Dr. Art Pyster, Chief Scientist for Software Engineering, and Dr. Herman Rediess, Chief Scientist for Test and Evaluation. The guidance produced will address the testability, certification, safety, and reliability of COTS software components in safety-critical systems.

Recommendation #8: The FAA should begin a research study, in collaboration with the Advanced Research Project Agency's (ARPA) Evolutionary Design of Complex Software (EDCS) project, to characterize and measure system complexity and its relationship to system architecture with the objective of reducing complexity in FAA safety-critical systems.

Response: The FAA agrees, and steps are being taken to implement this recommendation. Preliminary work has determined that real-time systems can be characterized by the number of attainable discrete states, including defined legal states (such as normal and exceptional operations), defined illegal states (such as hazardous or undesirable operations), and undefined states. The number of states can be calculated as the product of the total number of values, which are possible for each of the variables used to define the system. Complexity can then be measured as a function (e.g., the logarithm) of the number of states. Using a discrete state approach allows complexity to be directly related to system architecture. In particular, it allows a distinction between controlled and uncontrolled complexity, permitting the use

of very complex architectures which, nevertheless, can be shown to be consistent and correct. This is most easily accomplished by using a formal architectural language to characterize the architecture.

Recommendation #9: The FAA should establish a research program to develop explicit safety metrics, objectives, measures, etc. At a minimum, the metrics would be used to determine, via prototyping, if system A is safer than system B.

Response: The FAA agrees and currently is a partner with DOD, NASA, and the

United States Coast Guard (USCG) in the joint development of a software system safety handbook. This is a first step in evolving from a total reliance on quality assurance and good software engineering practices to the implementation of a software safety engineering discipline. A safety engineering discipline will employ metrics, measures, and hazard analysis practices to identify and define the safety critical elements of software specifications, requirements, and end product.

The Radio Technical Commission for Aeronautics (RTCA) document DO-178b is accepted within the aviation software community as a means for assuring the safety of software in avionics systems. The document currently is under review by RTCA Special Committee 190, which brings together experts from around the globe. The modifications to DO-178b will need to be carried out in concert with the development of ground-based software safety practices to ensure that ground, air-ground, and airborne software use common standards and provide a uniform level of confidence in overall system safety.

Aviation Weather

Recommendation #1: The FAA should facilitate the dissemination of consistent, common, and timely aviation weather information, in graphical format, to all users of the aviation system, both ground and airborne, as soon as possible. The FAA should take advantage of existing data links for this purpose. This could include licensing commercial vendors to have access to some fraction of existing links, such as Mode S, to provide weather graphics on a fee-for-service basis.

Response: The FAA strongly supports this recommendation and has long advocated the need for

parity in access to and dissemination of weather and flight information service (FIS) products among all NAS users. This position and policy are reflected in the NAS Architecture Version 3.0 (draft) and in the "Airborne Flight Services Policy Statement" signed by the Administrator May 1, 1998. Also, the weather and FIS planning for Flight 2000 is based on the same principle of common access and parity.

Recommendation #2: FAA policy statements and strategic plans should consider hazardous weather information as an aviation safety issue, as well as a capacity one.

Response: The FAA Administrator has signed an aviation weather policy statement that recognizes the role of aviation weather in the safe operation of the NAS. The statement, as well as agency strategic plan documents, addresses hazardous weather as a safety issue. These documents also reflect users' priorities to reduce delays and increase system efficiency. The Aviation Weather Directorate (ARW) has taken the lead for developing a National Aviation Weather Strategic Plan, published in April 1997, which directs the FAA and other agencies to pursue strategies and new systems for aviation weather that will enhance safety as well as system capacity. The plan also details the case for aviation weather initiatives by citing safety data such as accident and incident statistics.

Recommendation #3: The Associate Administrator for Research and Acquisitions, ARA-1, should establish a separate weather IPT within the AND organization, to focus the leadership and responsibility for all research, engineering, development, and implementation of weather projects.

Response: Weather research is vested in a single IPT in FAA's Office of Air Traffic Systems Development (AUA). Wake vortex research is performed in AND.

Recommendation #4: The FAA should support a weather architecture which includes the appropriate elements and interfaces needed to disseminate critical weather information to <u>all</u> aviation users, supported by adequate funding and priorities.

Response: The FAA agrees with this recommendation. The FAA will provide an integrated weather architecture that includes not only the sensor systems required to collect critical weather information, but also weather processing systems [i.e., Weather and Radar Processor (WARP) and Integrated Terminal Weather System (ITWS)] to support product dissemination. The WARP and ITWS will disseminate user-friendly products to *all* aviation users within the en route and terminal environments. Consequently, when controllers, specialists, pilots and dispatchers receive the same weather information from these weather 'servers', a 'common situational awareness' will be achieved, thereby improving safety and enhancing the efficiency of the NAS.

Recommendation #5: The FAA should continue to fund longer term (greater than 1 hour) convective weather prediction, and longer term (greater than 20 minutes) storm growth and decay forecasting R&D. These efforts are intended to develop improved techniques for sensor data analysis, assimilating sensor data into predictive models, and converting these model outputs into products that benefit air traffic and aircraft operators decision-making in convective weather.

Response: The FAA has a plan to conduct research to meet this goal.

Recommendation #6: The FAA should continue the research programs directed at improved 1 to 2 hour forecasting of ceiling and visibility at airports. This effort could be extended to allow improved ceiling and visibility (C&V) forecasts up to 6 hours.

Response: The FAA has a plan to conduct research to meet this goal. However, this effort is not funded in fiscal year 1998.

Recommendation #7: The FAA should fund a research program that builds on the National Center for Atmospheric Research (NCAR) research to develop a model whose output is an hourly gridded forecast of hazardous in-flight icing.

Response: The FAA has an ongoing program to conduct research to meet this goal.

Recommendation #8: The FAA should fund a research program, in conjunction with NASA, to exploit ITWS products to produce reliable short-term forecasts of key variables which most affect wake vortices.

Response: The FAA will continue coordination with the NASA program on research associated with providing wake vortex prediction capabilities, including initiatives that exploit ITWS capabilities.

Achieving New Aviation

System Capacity

Recommendation #1: Introduction of automation aids for controllers into en route and terminal operations to:

- Achieve optimal arrival sequencing.
- Provide guidance for staggered and converging arrivals.
- Achieve minimum required wake vortex spacing for operations to or from single, parallel and intersecting runways.
- Reduce inter-arrival variability by 50 percent or more.
- Reduce the need for pilot-to-controller voice communication.

Response: IPT's are pursuing the above initiatives to provide better utilization of airspace and runway capacities while operating in a safe environment with regard to wake vortices. Much of this work is being carried out in collaboration with NASA. An example of currently planned research activities includes development of arrival/departure decision support systems for increased efficiencies in arrival and departure, and development of an integrated decision support toolset for the en route environment.

Recommendation #2: Improvement in required separation standards and minimums:

- Reduction of required spacing for independent and dependent arrivals to parallel runways.
- Reduction of minimums for independent arrival operation to converging runways.
- Establishment of procedures for instrument flight rule (IFR) operations to closely spaced parallel, triple and quadruple runways.

Response: The Research, Engineering and Development (R,E&D) program has carried out a number of initiatives in the past that have resulted in reductions in the separation standards addressed in the recommendation. There are no initiatives

underway in this area at this time and none planned.

The R,E&D program is undertaking a comprehensive analysis of opportunities to improve system capacity and will examine the need for new efforts in this area.

Recommendation #3: Renewed effort to reduce operational impact of wake vortices.

Response: Further research is necessary into the effects of wake vortices upon capacity. Research during 1997 addressed wake vortex issues on an individual airport basis concerning the separation of takeoffs and landings. Research into a laser-based wake vortex detection capability is underway in 1998 with proof-of-concept demonstrations planned. At present, inclusion of a wake vortex project into the 2000 budget recommendation is underway.

Recommendation #4: Development of requirements and procedures for use of cockpit traffic displays to provide better information to pilots on the traffic situation and to permit pilot participation in approaching visual flight rules (VFR) capacity in IFR conditions.

Response: The R,E&D program developed the Traffic Alert and Collision Avoidance System (TCAS) and supported its worldwide implementation. TCAS provides a traffic situation display for the purpose of reducing the risk of midair collisions.

Currently, there is no significant work underway or planned in FAA or in NASA on more general applications of cockpit displays providing traffic information to flightcrews, e.g., applications focused on providing VFR system capacities in IFR conditions. It is expected that such research will be initiated in the future as higher priority tasks are completed. Research into this area is being examined as part of safety initiatives being worked with NASA.

Recommendation #5: Flow management and evolution to more cooperative ATC.

Response: Substantial research investments are now being made by FAA in the area of traffic flow management and collaborative decisionmaking with airspace users. The approach is based on spiral development of incremental improvements

with the stakeholders heavily involved in prioritizing the research and guiding the implementation of system enhancements.

Recommendation #6: Examination of the basis for current separation standards and criteria.

Response: FAA is in the process of implementing reduced vertical separation standards in oceanic airspace and developing CNS/ATM improvements to support reduced lateral and longitudinal separation standards over the ocean. Whereas most of the effort thus far has been expended in the reduction of oceanic separation standards, initiatives pertinent to other domains are underway. An Integrated Requirements Team (IRT) has been formed as part of the mission and analysis process where reduced separation standards for the en route and terminal domains are being explored. Additionally, a joint effort with Eurocontrol is underway where domestic separation standards are being addressed.

The FAA R,E&D program will continue to explore opportunities to enhance ATM system performance through reduced separation standards.

Recommendation #7: Weather information, both near terminals and aloft, needs to improve dramatically. Safety-related aspects -- wind shear, wake vortices, downburst protection, etc. -- have priority, but effective terminal and en route automation and sensible flow management require the best possible weather and wind gradient data. FAA should continue to work in partnership with other agencies, especially DOD and NOAA.

Response: A major thrust of the National Aviation Weather Strategic Plan is an emphasis to improve the quality of aviation weather information available to pilots, controllers and dispatchers to support improved, collaborative operational decisionmaking. The underlying theme of our aviation weather research is a focus on solving near-term operational problems related to safety and system capacity. R,E&D programs, which are heavily leveraged with other research both within and outside the Government, include the development of new and improved algorithms to model and predict weather events that affect aviation. There is also a limited basic research effort aimed at increasing the scientific understanding of the atmospheric processes associated with hazardous weather impacting aviation safety and capacity. These hazards include in-flight icing, turbulence, convective weather, and reduced ceiling and visibility.

Recommendation #8: Demonstration of capabilities and development of procedures to exploit the capabilities of satellite navigation.

Response: The FAA is continuing the acquisition and certification of satellite navigation services ranging from oceanic positioning through precision approach capabilities. Extensive R,E&D into the capabilities of GPS and satellite-based augmentation, WAAS and LAAS, is well underway and continuing.

Recommendation #9: Expedited development of procedures for beneficial application of GNSS/ Flight Management System (FMS) or equivalent systems to achieve precision arrival and departure paths, and more precise missed approaches.

Response: The FAA has developed and certified a number of FMS-guided terminal procedures for approaches, departures, and missed approaches in collaboration with the user community. This work is continuing in the Flight Standards Service and is funded in the Operations appropriation.

Recommendation #10: Improved safety of on-airport air traffic movement and control:

• By development of an automated, airspace-system-compatible, airport surface surveillance, guidance, and control system, which supports improved runway incursion control.

• By improving and standardizing airport lighting, signage, and marking to provide safe airport operation during runway entry, turnoff, departure and crossing, and reduced runway occupancy time.

Response: The FAA has a number of research efforts underway to reduce the risk of runway incursions, including the development of low-cost airport surface detection equipment intended to provide lower-activity towers with real-time radar surveillance of the airport surface. The FAA also is reviewing and addressing the recommendations of the R,E&D Advisory Committee document titled, "Report of the Subcommittee on Runway Incursions," dated January 29, 1998.

The FAA and NASA have developed a surface movement advisor capability that is intended to improve the efficiency of surface movements by providing tower controllers, airlines, and airport operators a comprehensive, consistent understanding of the surface traffic situation.

R,E&D in the airports technology area includes prototyping and test of an Advanced Taxiway Guidance System (ATGS) for visual guidance along airport taxiways. There is no significant research underway at FAA or NASA to develop an airport surface guidance and control capability. It is expected that such research may be initiated as higher priority activities are completed.

Recommendation A1: Optimize the present airport system including:

- Physical airfield and terminal improvements and expansion.

- Ground access enhancement.

- Procedural/operational changes and flow management.

- Use of new capacity technology.

Response: Airport sponsored R,E&D projects are actively supporting improved flow management and new technologies, which will be incorporated into the operating environment as they are developed. These projects include Airport Planning and Design, which will conduct research to support development of advisory circulars to provide updated guidance on terminal building planning and design. This replacement advisory circular will provide a modern computer-aided design process to improve airport design. The project will also support research on improving ground access including demonstration of high-occupancy vehicles (busses and vans) for airport access.

Recommendation A2: Add new airports in cities with the most serious congestion.

Response: It is expensive and difficult to add major new airports to metropolitan systems. In most instances, air carriers prefer to add capacity to existing airports gradually and to make better use of existing capacity by the use of larger aircraft and higher load factors. When new airports are added, they are typically reliever airports, allowing general aviation an alternative to the use of the congested air carrier airports. Sites are very difficult to obtain for major new airports in metropolitan areas. The conversion of surplus military airports to civil use is more easily achieved. FAA is currently working with more than 30 communities to help convert military airports to civil use.

Recommendation A3: Add a new type of airport, the "remote transfer airport."

Response: The concept of the remote transfer hub has been explored over the years. There is an FAA/industry consensus that there is no need to construct, or even designate, a class of airports in remote areas for relocating transfer functions from congested hubs. The airlines have indicated that the preferred locations for transfer hubs are existing airports which have good facilities and are located in major cities which can generate a large number of higher fare origin/destination traffic to supplement the lower fares paid by the transfer passenger. There is, at this time, no compelling reason or industry support to seek "remote" locations for transferring passengers.

Recommendation A4: Use new vehicle technology like the New Large Aircraft (NLA), VS-TOL's or even improved surface transportation to optimize the airport system.

Response: Larger aircraft are already an important factor in providing capacity at airports, which cannot be easily expanded. Forecasted growth rates of aircraft operations at congested airports are often only half the growth rate of passenger enplanements reflecting the greater seating per operation. FAA has made design standards for the NLA available to airports to assist in planning future development and is working with industry to identify and remove any barriers that stand in the way of a smooth introduction of these aircraft.

VSTOL's are recognized as having a potential role in the high-density, short-haul market and FAA has issued appropriate design guidance to airport engineers and planners. When remaining economic and marketing obstacles to their wider use are resolved, they may be able to contribute to metropolitan airport system capacity in a more meaningful way.

Improvements in surface transportation and communications technologies outside the aviation sphere already have effects, though difficult to

isolate, on aviation growth. An example is the sensitivity of Northeast Corridor airport traffic to AMTRAK service and fares. FAA is working in cooperation with other Department of Transportation (DOT) agencies to optimize ground access to airports and to encourage the development of an efficient national intermodal system.

Leveraging

Recommendation #1: FAA leadership recognize the critical necessity to leverage its own R&D resources and appreciate that the unique role of the FAA in providing ATM services for actual and potential FAA suppliers of ATM hardware and software to undertake R&D beyond the levels of the past.

Recommendation #2: FAA's recognition of this relationship be explicit and widely publicized.

Response to Recommendations #1 and #2: FAA is placing a greater R&D burden on industry through a number of program-specific initiatives:

- Acquisition Management Systems
- Coordinating specifications with industry
- Performance specifications and standards
- NAS architecture
- Cooperative R&D agreements

Recommendation #3: For both hardware and software that FAA requires, only performance specifications should be published (rather than design specifications); such performance specifications should be published broadly and reflect the FAA's vision for ATM in the future; they should also be updated with appropriate frequency to reflect changing technology.

Recommendation #4: Standards should be established well in advance of the deployment of hardware and software incorporating them and should be reviewed with the appropriate periodicity to ensure that requisite R&D is being done to enable suppliers to meet (or even exceed) such standards.

Recommendation #8: For FAA-acquired and operating systems, make decisions as to their attributes and performance requirements as far ahead of deployment as possible to enable potential suppliers and cooperators to commit maximal resources to supporting R&D.

Response to Recommendations #3, #4, & #8: We agree with the spirit of the recommendations. The FAA intends to use the NAS Architecture and its supporting standards and documents as a basis for informing industry of the intended further development of the NAS infrastructure. In addition, the agency will continue to work with industry through public forums and other mechanisms to foster its internal investments in the development of the systems the FAA requires. It is recognized that design specifications can stifle innovation in industry and, therefore, can be counterproductive. Where possible, the FAA intends to exploit equipment and capabilities that are commercially available in meeting NAS infrastructure needs.

Recommendation #5: It is recommended that the FAA make better use of the National Resource Specialist (NRS) concept in order to anticipate possible and practical technological changes.

Response: The FAA agrees with the recommendation. AVR uses NRS's extensively in the review of opportunities to exploit technology to improve the performance of the NAS. They also work closely with AVR policy offices and through them participate in the definition of R,E&D requirements with respect to airborne equipment design, production, and operational certification. With the recent expansion of the Aircraft Certification Service NRS program, it is anticipated that NRS participation in the management of technological changes will increase.

Recommendation #6: Announce and implement a policy to accommodate technological changes of merit with minimum delay.

Response: The recent activities of the NAS Modernization Task Force have focused specifically on near-term implementation of technological improvements to the NAS. In addition, the community-wide consensus to adopt a spiral-development approach to NAS modernization responds directly to the recommendation.

Recommendation #7: Exploit the concept of cooperation with industry to the extent it does not produce long-term, anti-competitive effects in the marketplace.

Response: The FAA agrees and is dedicated to the principle that NAS modernization can be ac-

complished only through community-wide collaboration of all stakeholders, including industry.

Response to the *Report and Minutes of the Subcommittee on Air Traffic Services* (Report dated November 6-7, 1997)

The Air Traffic Services Subcommittee in one of the six standing subcommittees established in January 1997 to provide recommendations to the FAA on its proposed R,E&D investment portfolio and to conduct annual reviews of FAA's research and development program.

The purpose of the Subcommittee's November 1997 meeting was to review and comment on the Flight 2000 initial program plan, the Operation Concept for 2005, and their integration with NAS Architecture Version 3.0 and the overall R,E&D program plan. The Subcommittee Report was approved by the Committee on January 29, 1998 and provided by letter to the Administrator on February 12, 1998. The following response was presented to the Committee by letter dated June 29, 1998.

Recommendation #1: In its program for ATM modernization, the FAA should give highest priority to increasing capacity, reducing delay, and improving safety. Allocation of resources should be in accord with this high priority.

***Response*:** We concur with the Subcommittee's recommendation to give the highest priority to increasing capacity, reducing delays, and improving safety. The Air Traffic Services (ATS) Target Area Team (TAT) proposed to the R,E&D Advisory Committee, Tier One fiscal year (FY) 2000 funding allocations for the Aviation System Capacity Research Project Description (RPD), Aviation Weather RPD, and Tower/Surface Automation RPD. These research programs are expected to increase the capacity of the U.S. aviation system to meet customer demand for aviation services, allow more flexibility in the use of resources for National Airspace System (NAS) users, and reduce weather-related accidents and incidents. In addition, the Runway Incursion Reduction, Separation Standards, and Aeronautical Data Link RPD's have been proposed for Tier One funding for FY 2000 by the ATS TAT.

Recommendation #2: The FAA should refocus Flight 2000 on the highest priority issues—safety,

capacity, and delay in capacity-constrained airspace—with emphasis on total system integration.

***Response*:** The concept for a program like Flight 2000 has evolved over several years, based on a realization that the challenge of the NAS modernization is in achieving new flight capabilities, not just installing new ground-based automation equipment. Flight 2000 will accomplish a manageable cross-section of total system integration, and validate the resulting flight capabilities in a real-world operational environment. The program is being refocused with greater emphasis on reducing the technical, operational, and institutional risks of NAS modernization. Communication, navigation, and surveillance (CNS) systems must be integrated, aircraft compatibly equipped, and operational procedures developed, for controllers and pilots to assess the benefits of advanced technology and thereby reduce the risks associated with modernizing the NAS.

Applying the CNS flight capabilities of Flight 2000 at higher density contiguous United States (CONUS) sites was originally conceived as an activity to transition the results of Flight 2000 to NAS-wide modernization. Based on a recent recommendation by the Air Traffic Services Subcommittee, Flight 2000 intends to add a CONUS site as an integral part of the program. We are currently analyzing candidate sites, based upon traffic density, prevalence of air carrier operations, numbers of aircraft equipped with Flight 2000 avionics, necessary CNS and air traffic management (ATM) ground equipment, and suitability of airspace. Once this work is complete, a set of criteria will be forwarded to the RTCA Free Flight Steering Committee for industry review and concurrence on a final site. The Select Committee has committed to providing its recommendations to the FAA by August.

The flight capabilities resulting from Flight 2000 development also will offer vastly improved pilot and controller situational awareness and the potential for collaborative decisions between pilots and controllers. Eventually, and under carefully managed situations, controllers may authorize pilots to maintain self-separation in instrument conditions similar to the visual separation instructions controllers routinely issue to pilots today. In

such an environment, controllers will be able to devote greater attention to managing the overall traffic situation to accommodate user-preferred trajectories. The results will be more efficient traffic flow without compromising safety.

For pilots to maintain instrument separation comparable to today's visual separation, both controllers and pilots will need a reliable, accurate, and consistent depiction of traffic, as well as an ability to identify positively specific aircraft. By integrating advanced CNS capabilities in a real-world environment, Flight 2000 will demonstrate and validate the feasibility and potential benefits of collaborative decision-making and pilot instrument separation responsibility. These new flight procedures will then permit controllers to employ fully the sophisticated ATM tools that promise substantial NAS capacity improvements for the future.

Recommendation #3: To enhance safety, the FAA should increase the priority for deploying the ground systems which transmit weather information to the cockpit, and should continue to support the development of affordable avionics for the display of weather and hazardous terrain.

Response: The FAA is committed to providing Flight Information Services (FIS) to pilots and has issued a policy statement which includes delivery of weather products to the cockpit. This policy statement was developed in conjunction with the general aviation user communities and industry. The policy enables the FAA and industry to partner in providing the services thus expediting the implementation of FIS. R,E&D activities necessary to develop standards and guidance materials for the implementation of FIS are contained within the Aeronautical Data Link R,E&D program and Flight 2000. Flight 2000 is a limited, real-world demonstration and validation of advanced operational capabilities. It is an R,E&D program focused on integrating technologies, developing procedures, and mitigating risks prior to a full-scale NAS deployment. As such, Flight 2000 is a key near-term learning effort in applying new CNS technology to the operational NAS. Critical decisions regarding subsequent Facilities & Equipment (F&E) programs to implement these technologies throughout the NAS will be heavily dependent on the validation results of

Flight 2000. Until these results are known, there is no basis for an investment decision to deploy the CNS systems Flight 2000 addresses.

Recommendation #4: The FAA should develop a plan for ATM modernization expressed in terms of quantitatively-defined goals for evolving operational capabilities and user benefits. The concept of operations and the architecture should be tied to this ATM Modernization Plan, and the R&D plans should in turn be tied to the concept of operations and the architecture (i.e., what R&D must be done, and when, to support these plans?).

Response: The FAA plans to expand both the concept of operations and the architecture to develop this plan for modernization. The architecture will be expanded to include identification and milestone planning for procedures and certification. We hope that by including these details, the architecture and its appendices will become the planning document for modernization.

The current architecture is logical based on the high-level concept of operations. The process for deriving a technical architecture is based on a feedback loop with the concept of operations. As the detail is added to the concept, it will increase the specificity by which the initial requirements for a capability can be defined. Where the concept is not clear or sufficiently detailed for deriving requirements, the push will be from the technical architecture to the concept developers to provide a basis for requirement definition.

The FY 2000 R,E&D plan used the architecture and the concept to validate current activities and identify needed R,E&D shortfalls. Many of the needs expressed in the RPD's beyond the current FY 1998 core were first identified in the process of rationalizing concept and architecture with R,E&D. The proposals and initial assignment to the funding tiers were based on the proposed architectural schedule for fielding capabilities. As the concept is developed and the architecture refined, the R,E&D requirements will also be refined and more closely tied to the modernization schedule.

It is clear that all capabilities and proposed paths to meeting the capabilities' shortfalls are not equal. Clear definition of the operational improvement sought and an understanding of the

current baseline performance are required to decide which capabilities to pursue and which solutions are tenable. In a concurrent and related activity, operational analysis will be conducted and performance measures will be developed to determine which steps are achievable and affordable. The activities pioneered by the System Capacity organization to define operational performance and value will be expanded as part of the continuing efforts of System Capacity, and performance definition and measurement is a key step in concept validation.

The clear articulation of the operational changes to be made and the method by which they will be measured will allow the FAA to develop clear performance baselines for capabilities as opposed to constituent systems. The baseline will allow tracking of all aspects to the delivery of new capabilities, such as systems, procedures, training, and airspace adaptation. The ARA performance plan goal 6 is the initial step in tracking capabilities in this fashion.

Recommendation #5: The Administrator should make sure that she is aware of the recommendations of the R,E&D Advisory Committee and other existing advisory committees, possibly by direct representation of these committees on the NAS Modernization Task Force.

Response: The FAA established the NAS Modernization Task Force to advise the Administrator on the next steps necessary to NAS Modernization. The task force began its work in November 1997 and held its last meeting in January of this year, having completed its requested task. It recommended that the FAA concentrate its modernization efforts on a subset of the proposed NAS Architecture and delay work on other parts until this first subset was accomplished. The recommended subset, labeled Free Flight Phase 1 (FFP1), consists of the following systems and controller tools: Passive Final Approach Spacing Tool; Traffic Management Advisory Single Center; Controller Pilot Data Link; User Request Evaluation Tool; Collaborative Decision-making with Airline Operations Centers; and Surface Movement Advisor.

Subsequently, the FAA has requested the RTCA Free Flight Steering Committee and its Free Flight Select Committee to provide oversight of the FAA's efforts in accomplishing the FFP1 tasks. Some members of the R,E&D Advisory Committee and its subcommittees are also members of the RTCA Free Flight Steering Committee and Select Committee. This dual membership should provide the recommended R,E&D Advisory Committee representation on committees that advise the Administrator on NAS Modernization.

Committee Recommendations on FY 2000 R,E&D Investments (Letter dated May 24, 1998)

At the April 23–24, 1998, Committee meeting, the Committee reviewed FAA's planned FY 2000-2004 R,E&D Investment portfolio with special emphasis on FY 2000. The Committee provided feedback to FAA in a May 24 letter from the Committee Chairman Mr. Ralph Eschenbach to Administrator Jane Garvey. The FAA will consider these recommendations as it finalizes its R,E&D budget and respond to the Committee on these recommendations between January and April 1999.

Recommendation #1: FAA should bring together, in a single organization within FAA, all aspects of the National Airspace System (NAS)—R,E&D, acquisition, operation and maintenance (but not certification)—headed by a person reporting directly to the Administrator. A small system team responsible for planning the evolution of the NAS should directly support this person. The system team should be made up of the best and brightest from both the operational and developmental parts of FAA. Other organizations and agencies can support this activity, but the responsibility and leadership must remain within FAA. The Committee emphasizes that strong, credible FAA leadership is mandatory for success. Such leadership must include the willingness to make decisions *when consensus cannot be achieved*. There continues to be a need to strengthen the number and competence of FAA's internal staff. Only with a strong internal capability can FAA make good use of outside support contracts.

Recommendation #2: Free Flight Phase 1 should be only the first step in a multi-step process. The rapid movement toward the full implementation of the operational concept and the new architecture is essential for the evolution of the NAS and

the continued leadership of the United States in the emerging global transportation system. Continued R&D effort will be required to achieve reduced separation standards in all domains and increased terminal and airport capacity to meet the growth projections of the next decade. The FAA weather program has developed a number of weather products, which can provide significant benefits to aircraft operations. The FAA should move aggressively to effect an operational deployment of these products, with emphasis on making them available to aircraft in flight.

Recommendation #3: FAA needs to address the certification process issue energetically, as it is a pacing item in NAS evolution. Certification must be end-to-end (ground and air) across the NAS.

Recommendation #4: Given the Administration's requested budget level, the Air Traffic Services' (ATS) budget of $50.1 million has the right program balance. However, the following R&D areas are not adequately funded in the $50.1 million ATS program. In fact, the ADS-B project, a cornerstone of the NAS modernization has been zeroed! We feel it is *crucial* that these projects be restored.

Area Additional Funding Required:

ADS-B	$2.5 million
Aviation Weather	$2.8 million
Flight System Technology	$0.8 million
En route Automation	$9.0 million
NAS Management	$3.0 million
Total	**$18.1 million**

Recommendation #5: For many R&D areas, there is significant R&D work being done in other nations, usually with public support. FAA must systematically identify such R&D efforts and gather the outcomes, as they become available. This will minimize duplication of effort and facilitate subsequent harmonization in appropriate matters.

Recommendation #6: FAA needs to rebuild and strengthen its leadership role in international aviation. A mismatch in ATM approaches regionally around the world will require international aircraft to have multiple systems on board their aircraft. We cannot allow this to happen.

Recommendation #7: FAA needs to pursue R&D partners, who benefit from the R&D that FAA conducts and can partially or fully fund the R&D effort. The FAA should systematically and regularly review each of its present and prospective research project descriptions to determine the major private and public agency beneficiaries of the R&D work either underway or proposed. This will identify likely R&D "partners." The value of the benefits for each such party should be estimated competently, and a proposal for joint funding of each R&D effort should, then, be developed. In the course of estimating the value of the benefits available to a prospective partner (an appropriateness analysis), FAA will find some instances in which such benefits exceed the cost required to achieve the R&D results -- often by a substantial amount. Such cases are candidates for the transfer of perhaps all the costs of such R&D to the other parties, thus enabling FAA to use its own resources to pursue R&D which, otherwise, would not be undertaken.